VERIFICATION OF TRANSLATION

I, Setsuko Nakata of 12-16, Sakuragaoka 1-chome, Kugenuma, Fujisawa-shi, Kanagawa-ken, Japan, am familiar with Japanese and English languages. I prepared the attached English translation of Japanese Patent Application No.2004-194381. It is an accurate translation, to the best of my ability.

Signed at Tokyo, Japan

This 20th day of November, 2007

Setsuko Nakata

By: Setsuko NAKATA

[Title of the Invention] VERTICAL AXIS WINDMILL AND VERTICAL MAIN SHAFT

[Scope of Claim]

[Claim 1] A vertical axis windmill in which elongated blades are vertically arranged in multiple stages and attached to one vertical main shaft disposed within a shaft-installation section of a support frame characterized in that the number of the blades in each of the stages is one, the blade is arranged with a left-side surface thereof being opposed to the vertical main shaft, tilted parts facing to the left side are formed on an upper end and a lower end of the blade, and each of phases on a plane of the blades is shifted by an equal angle in a rotational direction from a phase of a blade in an immediate upper stage thereof so that the blades are equally spaced around the main shaft as a whole on the plane.

[Claim 2] A vertical axis windmill according to claim 1 further characterized by that a chord length of the blade is set to a length corresponding to 50 to 60 percent of a radius of rotation of the blade.

[Claim 3] A vertical axis windmill in which elongated blades are vertically arranged in multiple stages and attached to a vertical main shaft disposed within a shaft-installation section of a support frame characterized by that the number of the blades in each of the stages is two, each of the blades are

symmetrically arranged with a left-side surface of each of the blades being opposed to the main shaft, tilted parts facing to the left side are formed on an upper end and a lower end of each of the blades, and each of phases on a plane of pairs of the blades is shifted by an equal angle from a phase of a pair of blades in an immediate upper stage thereof in a rotational direction so that the pairs of blades are equally spaced around the main shaft as a whole on the plane.

[Claim 4] A vertical axis windmill according to claim 3 further characterized by that a chord length of the blade is a length corresponding to 40 to 50 percent of a radius of rotation of the blade.

[Claim 5] A vertical axis windmill according to any one of claims 1 through 4 further characterized by that the vertical main shaft is supported by intermediate bearings at intermediate positions thereof, and the blade is arranged between an upper one and a lower one of the intermediate bearings.

[Claim 6] A vertical axis windmill according to any one of claims 1 through 5 further characterized by that the vertical main shaft is covered by a reinforcement material excepting portions received by the bearings and vicinity thereof.

[Claim 7] A vertical axis windmill in which a plurality of vertical shaft-installation sections

are formed inside a support frame configured by a plurality of posts, elongated blades are vertically arranged in multiple stages and attached to a vertical main shaft disposed in each of the shaft-installation sections with a left-side surface of each of the blades being opposed to the vertical main shaft to form the vertical axis windmill characterized by that tilted parts facing to the left side are formed on an upper end and a lower end of the blade, and each of phases on a plane of the blades is shifted by an equal angle from a phase of a blade in an immediate upper stage thereof in a rotational direction so that the blades are equally spaced around the main shaft as a whole on the plane.

[Claim 8] A vertical axis windmill according to claim 7 further characterized by that, in the vertical axis windmill in which a plurality of the vertical main shafts are disposed inside the support frame, the number of the stages of the blades on one vertical main shaft differs from that of the stages of the blades on a neighboring vertical main shaft.

[Claim 9] A vertical axis windmill according to claim 7 further characterized by that, in the vertical axis windmill in which a plurality of the vertical main shafts are disposed inside the support frame, positions of the plural vertical main shafts vertically arranged are alternately set fore or aft

on a plane of phase.

[Claim 10] A vertical main shaft of a vertical axis windmill characterized by that a reinforcement member is integrally formed on a surface of the vertical main shaft excepting a portion received by a bearing and vicinity thereof.

[Claim 11] A vertical main shaft of a vertical axis windmill characterized by that a fitting projection portion is formed on an upper end of the vertical main shaft, while a fitting recess portion is formed on a lower end of the same, the fitting projection portion is fit into a fitting recess portion of another vertical main shaft to connect the vertical main shafts to one another.

[Claim 12] A vertical main shaft of a vertical axis windmill characterized by that fitting portions are formed on both ends of the vertical main shaft, an end of a connecting shaft is fit into one of the fitting portions so that a plurality of the vertical main shafts can be connected to one another via the connecting shaft.

[Detail Description of the Invention]

[Technical Field]

[0001]

The present invention relates to a vertical axis windmill and a vertical main shaft. Particularly, the present invention relates to a vertical axis

windmill in which a support frame is formed as a wind power dam and a number of blades are arranged therein so that a rate of catching wind is increased, the area that can catch wind and a force of caught wind per installation area are increased, the cost of installation is reduced and an earogenerator being able to generate a large amount of electricity can be realized, and a vertical main shaft for use in the vertical axis windmill.

[Background Art]

[0002]

Vertical axis windmills have not been employed as windmills for use as earogenerators because of their poor rates of obtaining wind powers. A reason of this is that when a plurality of blades are arranged around a vertical main shaft and blades on one side of the vertical main shaft rotate by receiving wind, blades on the other side of the vertical main shaft are affected by resistance of the wind and the rotational force of the blades are thus cancelled. In addition, a single blade has a small axial torque, lacking serviceability.

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0003]

General aerogenerators of a propeller type have propellers of a length of, for example, 30 m or 50

m even though an area in which a post of the aerogenerator is installed is small. Therefore, an area served to such an aerogenerator is considerably wide.

Even a vertical axis windmill needs a wide area when a radius of rotation of the windmill is large. As a result, a purchase cost, a rent or the like of the ground would not be ignorable if consideration is given to a profit from generated electricity.

[0004]

A large-sized aerogenerator has to be installed in a place where excellent conditions of wind are available, which causes an increase in amount of investment in order to build a road to the aerogenerator, to assemble the same in the site, to collect generated electricity and so forth. Such costs largely effect on payability of the generated electricity.

[0005]

An object of the present invention is to provide a vertical axis windmill that can remarkably increase an area that can catch wind per windmill installation area, and can decrease the installation cost by decreasing the windmill in size and weight, the vertical axis windmill being also suitable for use as an aerogenerator.

[0006]

To solve the above problems and accomplish the above object, the present invention attaches vertically a plurality of blades to one vertical main shaft, and collectively sets a plurality of the vertical main shafts as one unit. Practical contents of the present invention are as follows.

[0007]

(1) A vertical axis windmill in which elongated blades are vertically arranged in multiple stages and attached to on one vertical main shaft disposed within a shaft-installation section of a support frame characterized in that the number of the blades in each of the stages is one, the blade is arranged with a left-side surface thereof being opposed to the vertical main shaft, tilted parts facing to the left side are formed on an upper end and a lower end of the blade, and each of phases on a plane of the blades is shifted by an equal angle from a blade in an immediate upper stage thereof in a rotational direction so that the blades are equally spaced around the main shaft as a whole on the plane.

[0008]

(2) A vertical axis windmill cited in the above item (1) further characterized by that a chord length of the blade is set to a length corresponding to 50 to 60 percent of a radius of rotation of the blade.

[0009]

(3) A vertical axis windmill in which elongated blades are vertically arranged in multiple stages and attached to a vertical main shaft disposed within a shaft-installation section of a support frame characterized by that the number of the blades in each of the stages is two, each of the blades are symmetrically arranged with a left-side surface of each of the blades being opposed to the main shaft, tilted parts facing to the left side are formed on an upper end and a lower end of each of the blades, and each of phases on a plane of pairs of the blades is shifted by an equal angle from a pair of blades in an immediate upper stage thereof in a rotational direction so that the pairs of blades are equally spaced around the main shaft as a whole on the plane.

[0010]

(4) A vertical axis windmill cited in the above item (3) further characterized by that a chord length of the blade is a length corresponding to 40 to 50 percent of a radius of rotation of the blade.

[0011]

(5) A vertical axis windmill cited in any one of the above items (1) through (4) further characterized by that the vertical main shaft is supported by intermediate bearings at intermediate positions thereof, and the blade is arranged between an upper one and a lower one of the intermediate

bearings.

[0012]

(6) A vertical axis windmill cited in any one of the above items (1) through (5) further characterized by that the vertical main shaft is covered by a reinforcement material excepting portions received by the bearings and vicinity thereof.

[0013]

(7) A vertical axis windmill in which that a plurality of vertical shaft-installation sections are formed inside a support frame configured by a plurality of posts, elongated blades are vertically arranged in multiple stages and attached to a vertical main shaft disposed in each of the shaft-installation sections with a left-side surface of each of the blades being opposed to the vertical main shaft to form the vertical axis windmill characterized by that tilted parts facing to the left side are formed on an upper end and a lower end of the blade, and each of phases on a plane of the blades is shifted by an equal angle from a phase of a blade in an immediate upper staged thereof in a rotational direction so that the blades are equally spaced around the main shaft as a whole on the plane.

[0014]

(8) A vertical axis windmill cited in the above

item (7) further characterized by that, in the vertical axis windmill in which a plurality of the vertical main shafts are vertically disposed within the support frame, the number of the stages of the blades on one vertical main shaft differs from that of the stages of the blades on a neighboring vertical main shaft.

[0015]

(9) A vertical axis windmill cited in the above item (7) further characterized by that, in the vertical axis windmill in which a plurality of the vertical main shafts are vertically disposed within the support frame, positions of the plural vertical main shafts vertically arranged are alternately positioned fore or aft on a plane of phase.

[0116]

(10) A vertical main shaft of a vertical axis windmill characterized by that a reinforcement member is integrally formed on a surface of the vertical main shaft excepting a portion received by a bearing and vicinity thereof.

[0017]

(11) A vertical main shaft of a vertical axis windmill characterized by that a fitting projection portion is formed on an upper end of the vertical main shaft, while a fitting recess portion is formed on a lower end of the same, the fitting projection

portion is fit into a fitting recess portion of another vertical main shaft to connect the vertical main shafts to one another.

[0018]

(12) A vertical main shaft of a vertical axis windmill characterized by that fitting portions are formed on both ends of the vertical main shaft, an end of a connecting shaft is fit into one of the fitting portions so that a plurality of the vertical main shafts can be connected to one another via the connecting shaft.

[Effects of the Invention]

[0019]

The present invention provides the following effects.

[0020]

(1) In the vertical axis windmill cited in claim 1, a plurality of elongated blades in multiple stages are attached to one vertical main shaft, with one blade in one stage. An output per installation area is ((rotation torque of blade in one stage) by (the number of stages)), thus the windmill can obtain a large rotational force form one vertical main shaft.

A single blade of the windmill has a larger rotational speed but a smaller axial torque because the blade is of an smaller area that can catch wind, lacking serviceability. However, when a plurality

of blades are arranged in multiple stages, an excellent rotation efficiency is attained in each stage, and turbulence generated by a front blade rotating in prior hardly affects on the rear blade.

On a plane, each of phases of the blades is shifted by an equal angle from that of a blade in an immediately upper stage thereof so that the blades are equally spaced around the main shaft on the plane as a whole. Accordingly, it is possible to catch winds in all directions as the whole windmill. Further, the windmill can catch different flows of wind passing through the upper portion and the lower portion thereof to obtain rotational forces therefrom. When a blade in any stage rotates by receiving wind, the other blades rotate by the force of this rotating blade. On this occasion, a self-running lift (rotational thrust) generates due to a shape (wing-like shape) of the blade, which overwhelms a resistance of the wind.

In particular, since the tilted parts are formed on the upper and lower ends of the blade, wind striking onto the left-side surface of the blade and escaping toward the upper portion and lower portion of the blade where resistance is small is obstructed by the tilted parts and presses the blade outwards, which increases the rotation efficiency. When this effect is applied to an aerogenerator, excellent efficiency

can be obtained.

Multiple stages of the blades can decrease the longitudinal length of a single blade, can facilitate transportation and assembling of the windmill, and can provide an effect better than one provided by a large-sized blade type even though an area in which the windmill is installed is small.

The support frame is formed by a plurality of posts, the posts not supporting a load of the entire vertical main shaft. Therefore, it is possible to give rigidity to the support frame with use of posts that are as thin as possible so far as it can endure the shearing load. Such support frame facilitates transportation, assembling, etc., and is effective to reduce costs such as the installation cost and the electricity generation cost when the windmill is used as an aerogenerator. Since the support frame is positioned outside the blades, the support frame is prone not to be shaken or vibrated due to rotation of the blades, wind pressure, etc.

[0021]

(2) In the vertical axis windmill cited in claim 2, the chord length of the blade is set to a length corresponding to 50 to 60 percent of a radius of rotation of the blade. This chord length is considered to be large as a chord length of an elongated blade of a vertical axis windmill. However,

the blade of this invention does not rapidly stall even when the power of wind decreases in spite of such large chord length, and can provide a strong rotational torque even during low-speed rotation.

[0022]

(3) In the vertical axis windmill cited in claim 3, two blades are symmetrically arranged, sandwiching the vertical main shaft, in multiple stages. The rotation efficiency of the blades in each stage is inferior to that of the single blade, but a pair of the blades have better rotation stability to allow the windmill to have excellent rotation efficiency as a whole. Other advantages are similar to those provided by one cited in claim 1.

[0023]

(4) Since the vertical axis windmill according to the invention cited in claim 4 is of a two-blade type, the chord length of each of blades has to be smaller than that of a single-blade type so as to avoid degradation of the rotation efficiency. However, a narrower width causes a decrease in rotational torque when the wind weakens. On the other hand, an excessively long chord length causes a large wind resistance. This invention can provide an efficient rotational torque even though the chord length of the blade is increased up to a length corresponding to 40 to 50 percent of a radius of rotation of the blade.

[0024]

(5) In the vertical axis windmill according to the invention cited in claim 5, the vertical main shaft is supported by the intermediate bearings at intermediate positions thereof. For this, even when the vertical main shaft is long and thin, the vertical main shaft is prone not to be bent, and the blades can be advantageously arranged in multiple stages.

[0025]

(6) In the vertical axis windmill according to the invention cited in claim 6, the vertical main shaft is covered by a reinforcement member. Even when the vertical main shaft is thin and long, the vertical main shaft can have excellent rigidity. When the reinforcement member is made of a FRP material or a light alloy, it is possible to decrease the diameter of the main shaft to decrease the entire weight. This can reduce the burden caused by that the blades are disposed in multiple stages, and can increase the rotation efficiency.

[0026]

In the vertical axis windmill cited in claim 7, a plurality of vertical shaft-installation sections are formed within one support frame, and the vertical main shaft is supported in each of the shaft-installation sections.

This support frame acts as a large wind power

dam, a power of wind collected by one support frame causes blades vertically arranged in multiple stages on each of the vertical main shafts to rotate, a collection of such large powers rotates a generator connected to each of the vertical main shaft. Accordingly, one support frame acts as one windmill, which accomplishes an aerogenerator generating a large electric power.

For example, when the number of stages of the blades on one vertical main shaft is ten and ten vertical main shafts are installed in line, an area that can receive the wind corresponds to a sum of the areas of 100 blades. This means that one support frame acts as one wind power dam, a power of wind collected by this wind power dam rotates all the vertical main shafts to generate electricity.

The support frame in which a plurality of the vertical shaft-installation sections are formed has a large area as a whole, and can be formed by a combination of thin posts or the like, which reduces the installation cost, and can keep strong rigidity in case of typhoon or earthquake.

Since the back of the windmill is in a windless condition, the support frame installed in a site where the wind is strong can have excellent efficiency of electric power generation, and can also serve as a windbreak.

[0027]

(8) In the vertical axis windmill according to the invention cited in claim 8, the number of stages of the blades differs from that of neighboring blades. For this, this vertical axis windmill is excellent in ventilation of each blade, and has a smaller effect of turbulence during rotation.

Particularly, when a plurality of the shaft-installation sections are set on an uneven ground, it is possible to install the vertical axis windmill, suitably to configuration of the ground.

[0028]

(9) In the vertical axis windmill according to the invention cited in claim 9, positions of the vertical main shafts vertically disposed are alternately set fore or aft on a plane of phase. For this, it is possible to avoid occurrence of a state where the windmill partially fails to catch the wind because one vertical main shaft is positioned behind another one against the wind.

Namely, when the support frame is formed with an elongated shape extending east to west, it means that wind blowing from the east or west passes through the support frame from the east or west, thus part of the blades are difficult to receive the wind. With the above structure, the vertical axis windmill has good ventilation to make good use of the wind power.

[0029]

In the vertical axis windmill according to the invention cited in claim 10, the surface of the vertical main shaft is integrally covered by a reinforcement member excepting a portion received by the bearing and vicinity thereof. Even when the long metal main shaft is thin, the vertical main shaft is not bent by centrifugal force or wind pressure during rotation.

Use of the reinforcement member enables the metal vertical main shaft to be thin. When the reinforcement member is made of an FRP or aluminum, it is possible to decrease the weight of the vertical main shaft as a whole. This makes it easy to realize multiple stages of the blades.

[0030]

(11) In the vertical main shaft according to the invention cited in claim 11, a plurality of short shafts can be connected to one another, which facilitates transportation, assembling the support frame and disposing vertically a plurality of the blades.

[0031]

(12) In the vertical main shaft according to the invention cited in claim 12, a plurality of short vertical main shafts can be connected via a connecting shaft, which facilitates assembling and

transportation of the vertical main shaft. By decreasing the diameter of the connecting shaft, it becomes possible to use a small-sized bearing, which decreases the friction area to increase the efficiency of rotation.

[Best Modes for Carrying Out the Invention]

[0032]

a plurality of blades are vertically arranged in multiple stages on one vertical main shaft disposed inside a support frame, with the blades being equally spaced on a plane of phase. A plurality of the vertical main shafts are vertically disposed inside one support frame to form one windmill.

[Embodiment 1]

Hereinafter, embodiments of the present invention will be now described with reference to the drawings. FIG. 1 is a front elevation view of essential parts of a vertical axis windmill according to a first embodiment of this invention. FIG. 2 is a plan view of essential parts, showing phases of blades of the vertical axis windmill on a plane. A support frame (4) has intermediate fixing arms, diagonal braces and so force, which are not shown in the drawings. A bottom end of the support frame (4) is secured on a concrete foundation not shown.

[0034]

In FIG. 1, in the vertical axis windmill (1),

a shaft-installation section (4a) is formed within the support frame (4) made up of a plurality of posts (2) and fixing arms (3).

In the shaft-installation section (4a), a vertical main shaft (5) is disposed and rotatably supported by upper and lower bearings (6). The posts (2) can be formed by tubular members, L-shaped members, H-shaped members, U-shaped members or the like, or formed by connecting a plurality of short parts.

[0035]

A base (7) in FIG. 1 has a box-like shape. Inside the base (7), disposed is a bearing not shown to support a lower end of the vertical main shaft (5). When an electric generator not shown is disposed inside the base (7) and is connected to the vertical main shaft (5) via an arbitrary power transmission means, the support frame (4) as a whole can function as an aerogenerator.

[0036]

To the vertical main shaft (5), fixed are plural sets of upper and lower fixing members (8) along the length of the vertical main shaft (5). The fixing member (8) has, for example, a disk-like shape with a hole formed in the center thereof to be fitted onto and fixed to the vertical main shaft (5). Alternatively, the fixing member (8) may be formed

by two pieces, which have shapes obtained by cutting the fixing member (8) into a left-side portion and a right-side portion, for example, and the left-side and right-side portions may be pressed onto the vertical main axis (5) from the left side and the right sides and fixed to the same with screws.

[0037]

Two fixing members (8), an upper one and a lower one, make a pair. In FIG. 1, four pairs of the fixing members (8) are uniformly spaced. On each pair of the fixing members (8), upper and lower support arms (9) making a pair are attached in parallel. A base end of each of the support arms (9) is fixed to the fixing member (8) with a screw. A space between the upper and lower support arms (9) making a pair is beforehand determined on the basis of a height of a blade (10).

Incidentally, when three support arms (9) are arranged, three fixing members (8) are used as one set.

[0038]

Directions pointed by tips of the sets of the support arms (9) differ from each other. As shown in FIG. 2, the uppermost set of support arms (9a) is directed to the front. The second set of the support arm (9b) is shifted by about 90 degrees in the rotational direction (denoted by an arrow A) from the

uppermost set and disposed.

[0039]

The third set of the support arms (9c) is shifted by 90 degrees in the rotational direction from the second set and disposed. The fourth set of the support arms (9d) is shifted by 90 degrees in the rotational direction from the third set and disposed. The rotational direction may be clock-wise or counterclock-wise.

[0040]

A sum of the shifted angles of the support arms (9a) to (9d) from the uppermost set to the lowermost set is 360 degrees, that is, four stages each of 90 degrees. As shown in FIG. 2, these sets of the support arms (9a) to (9d) are uniformly spaced at 90 degrees apart on a plane of phase.

[0041]

To tips of each set of the upper and lower support arms (9a-9d), fixed at right angles is an elongated blade (10), with a left-side surface (an inner-side surface at the time of rotation) thereof being opposed to the vertical main shaft (5) as shown in the front view in FIG. 1. A manner of fixing the blade (10) to the support arms (9a-9d) may be suitably selected from among fixing with screws, bonding, FRP integral fixing and so forth according to the size, weight and the like of the blade (10).

[0042]

The support arm (9) has sufficient rigidity that can support the blade (10), and has a shape that has small resistance to the wind. The support arm (9a-9d) shown is made of an FRP plate of say 5 mm thick.

A reason of this is that the blade (10) is light weight.

[0043]

Since the blade (10) has to be lightweight, the blade (10) is configured with a core which is integrally made of a rigid foamed resin and an FRP outer layer integrally formed thereon, for example. Aggregate may be used to make the core.

The blade has a height of 100 to 180 cm, and a thickness of 4 to 6 cm, for example. The chord length of the blade is changed according to the radius of rotation and the number of the blades. In the case of a single-blade type, the chord length of the blade is set within a range from 50 to 60 percent of the radius of rotation of the blade. In the case of a two-blade type, the chord length of the blade is set within a range from 35 to 50 percent of the radius of rotation of the blade.

[0044]

Upper and lower ends of the blade are inclined toward the left side of the blade when looked from the front to form tilted parts (10a). When the angle

of the tilted part (10a) is larger than 45 degrees, the performance of letting the wind pass through is degraded. When the angle of the tilted part (10a) is too small, the rate of catching the wind is decreased. Accordingly, a preferable angle is within a range from 30 to 45 degrees.

[0045]

As a shape of cross section of the blade (10), the right-side surface (the outer-side surface at the time of rotation) is along a curve of the rotational track of the blade (10), while the left-side surface is formed with an expanded portion on the front portion of the blade (10) so that the right-side surface (the outer-side surface) of the blade (10) has a small resistance to the wind at the time of rotation. The expanded portion increases the velocity of the wind passing along the inner-side surface of the blade rather than the outer-side surface of the same to generate an aerodynamic lift so that the blade self-rotates when rotated by a wind received by other blade.

[0046]

In FIG. 1, the height of the vertical main shaft (5) is, for example, 7 m. The outer surface of the vertical main shaft (5) is covered by a reinforcement member (5a) excepting portions received by the bearings and vicinity thereof. The reinforcement

member (5a) is made of only an FRP molded material or an aluminum molded material, or a combination of them, for example.

[0047]

The reinforcement material (5a) covers the fixing members (8), too, from the outside of the fixing members (8), thereby to improve the resistance to weather of the fixed portions and the like of the support arms (9a) to (9d).

In this case, the molded member of the reinforcement material (5a) and its connecting portions may be filled with a soft FRP resin and the FRP resin may be hardened, thereby to connect them.

[0048]

Even if the height of the blade (10) is as short as 1 m, for example, the vertical axis windmill with the above structure can provide a strong axial torque when rotating because the vertical axial windmill has four blades in four stages on the main shaft (5) having a height of, for example, 7 m, which realizes a wide area that receives the wind.

[0049]

Single blade (10) in each stage is free of a resistance to wind when the blade (10) is positioned on the opposite side of the vertical main shaft (5) on the same level, providing high rotation efficiency. Since the directions of the blades (10) in the

respective stage differ by 90 degrees from one another, the vertical axis windmill can provide a strong axial torque like a four-cylinder engine with the aid of a force of the smooth, continuous wind.

[0050]

In this case, when one blade rotates by receiving the wind, the other blades, which receives the wind as resistance, rotate by a force of the one blade. On this occasion, the shape of the blade generates an aerodynamic lift, which gives a self-running thrust to the blade so that the blade rotates by itself.

[0051]

The high vertical main shaft (5) has to be as thin as possible so far as the vertical main shaft (5) can stand to the shearing load in order to decrease the weight. As a result, the thin vertical main shaft (5) may be bent by a centrifugal force at the time of rotation and a wind pressure on the blades (10). However, the vertical main shaft (5) is integrally converted on its outer surface by the reinforcement member (5a) made of an FRP or a light alloy such as aluminum, which is light-weight and rigid, so that the vertical main shaft (5) can stand without being bent when rotating. Since FRP can be molded to have a light weight, the vertical main axis (5) can be light-weight as a whole, which increases the rotation

efficiency.

[0052]

In the first embodiment, the blades (10) are arranged in four stages. Alternatively, the blades (10) can be arranged in twelve stages, with three vertical main shafts (5) being connected in series, for example.

Still alternatively, the blades (10) can be arranged in, for example, three or six stages, with the length of the vertical main shaft being decreased. In which case, the blades (10) in the uppermost to lowermost stages can have different heights. In the case of a single blade in each stage, it is possible to generate a large axial torque by increasing the chord length of the blade.

[0053]

The chord length of the blade (10) changes according to the radius of rotation of the blade (10). For example, the chord length of the blade (10) can be increased within a range of length corresponding to 50 to 60 percent of the radius of rotation of the blade (10). Concretely, when the radius of rotation of the blade (10) is 1 m, the chord length can be increased up to 50 cm to 60 cm.

A short chord length of the blade (10) provides a fast rotational speed but a small axial torque. Accordingly, the blade can rotate at a high speed when

wind is present, but when the wind has fallen, the rotational speed is reduced as well as the axial torque. By increasing the chord length, it becomes possible to provide a large torque at a low rotational speed even when the wind has fallen.

[0054]

With rotation of the blade (10), the air rotates on and along the side surface of the blade (10) because of viscosity of fluid. As a result, a flow of the wind that gets into the rotation track of the blade (10) flows toward the upper portion and the lower portion of the blade having small resistances. When the tilted parts (10a) are formed on the upper and lower ends on the left-side surface (inner-side surface) of the blade (10), a flow of the air heading towards the upper portion and the lower portion of the blade (10) is obstructed by the tilted parts (10a) and presses the blade (10) in the rotational direction. Therefore, the rotational efficiency of the blade (10) with the tilted parts (10) is increased by 5 to 20 percent as compared with a blade without the tilted parts (10a).

[Second Embodiment]

[0055]

FIG. 3 is a front view of essential parts of a vertical axis windmill according to a second embodiment of this invention. FIG. 4 is a plan view

of essential parts of the vertical axis windmill. Wherein, like reference characters designate like or corresponding parts in the preceding drawings, detailed descriptions of which are thus omitted.

In FIGS. 3 and 4, illustrations of intermediate fixing arms, diagonal braces and so forth of the support frame (4) are omitted.

[0056]

The vertical main shaft (5) is supported by a plurality of intermediate bearings (66) at its intermediate portions. Each of the intermediate bearings (66) is fixed by the fixing arm (3) extending between the posts (2).

Whereby, the vertical main shaft (5) can resist larger bending forces as a whole, hence the metal vertical main shaft (5) can be as thin and lighter-weight as possible so far as the vertical main shaft (5) can endure shearing loads. By covering the outer surface of the vertical main shaft (5) by the reinforcement material (5a) excepting portions received by the bearings and vicinity thereof, the metal vertical main shaft (5) can be further thinner and lighter-weight.

[0057]

As the blades (10) arranged in the uppermost to the lowermost stages, two blades (10) face to each other across the vertical main shaft (5), just like

sandwiching the vertical main shaft (5).

In the case where the blades (10) is of a two-blade type, a smaller chord length of the blades (10) (a front-rear width) relative to the single-blade type is more advantageous with respect to resistance to wind.

When the radius of rotation of the blade (10) is 1 m, for example, it is preferable that the chord length of the blade (10) be set to a length corresponding to up to 40 to 50 percent of the radius.

[0058]

Each pair of the support arms (9a-9e) on the same level are set on the same diametrical line. Whereby, a pair of the blades (10) on the same level can keep excellent balance when rotating, which improves the balance of the windmill (1) as a whole.

[0059]

With respect to phases on a plane of the support arms (9a) to (9e) arranged in the uppermost to lowermost stages, the uppermost support arm (9a) is directed to the left and right, as shown in FIG. 4. The support arm (9b) in the second stage is set in a position shifted by 72 degrees from the uppermost support arm (9a) in the rotational direction (denoted by an arrow A).

[0060]

The support arm (9c) in the third stage is set

in a position shifted by 72 degrees in the rotational direction from the support arm (9b) in the second stage. The support arms (9d) and (9e) in the fourth and fifth stages each is set in a position shifted by 72 degrees in the rotational direction from an immediate upper support arm thereof.

[0061]

When looked down from the above, the phases on a plane of the support arms (9a) to (9e) are shifted by 36 degrees from one another in the rotational direction in the order: (9a), (9d), (9b), (9e), (9c), (9a), (9d), (9b), (9e) and (9c), as shown in FIG. 4.

[0062]

According to the second embodiment, the vertical axis windmill (1) has ten blades (10) in total. This means that the area that can receive the wind is increased to provide a larger axial torque. Particularly, the area that receives the wind of the windmill (5) of the five-stage blade type can be five times that of the windmill (5) of the single-stage blade type if these windmills (5) occupy the same installation area. Accordingly, the area that can receive the wind of the windmill (5) of the five-stage blade type is overwhelmingly large, which allows this windmill to exhibit a better performance.

[0063]

Since the phases on a plane of the blades (10)

are shifted by 36 degree from one another in the rotational direction as shown in FIG. 4, any one of the blades (10) can obtain a force of wind even when the wind is of a type that changes its direction instantaneously. In the case of wind blowing from one direction, the blades (10) can obtain stable rotational force from smooth, continuous force of the wind, like a ten-cylinder engine of the automobile.

[0064]

In the second embodiment, the blades (10) are arranged in five stages. However, the blades (10) may be arranged in ten stages by connecting two vertical main shaft (5) to each other.

Alternatively, the vertical main shaft (5) may be decreased in length, and the blades (10) may be arranged in, for example, three or four stages. In which case, the blades (10) arranged in respective stages may have different heights.

[Third Embodiment]

[0065]

FIG. 5 is a front view of essential parts of a vertical axis windmill according to a third embodiment of this invention. Wherein, like reference characters designate like or corresponding parts in the preceding drawings, descriptions of which are thus omitted.

In FIG. 5, illustrations of intermediate fixing

arms and diagonal braces of the support frame (4) are omitted.

[0066]

The third embodiment is characterized by that a plurality of shaft-installation sections (4a) are formed inside one support frame (4), and a plurality of the vertical main shafts (5) are disposed. In FIG. 5, two shaft-installation sections (4a) are depicted. However, the shaft-installation sections (4a) may be formed, for example, ten or 20 in number, coupled to one another.

[0067]

Inside one support frame (4), a number of shaft-installation sections (4a) are formed and the vertical main shaft (5) is disposed in each of the shaft-installation sections (4a). A plurality of blades (10) are mounted in multiple stages on each of the vertical main shaft (10), but directions of the blades (10) differ from one another. This enables the wind to easily pass through, and reduces interference of lows of wind generated by the neighboring blades when the blades rotate.

[0068]

In the vertical axis windmill (1) with the above structure according to the third embodiment, a plurality of the shaft-installation sections (4a) are formed inside one support frame (4), forming one

vertical axis windmill (1) as a whole.

The area that can receive wind of one blade (10) is small. However, a number of blades (10) are mounted in multiple stages on one vertical main shaft (5), and a number of the vertical main shafts are vertically disposed. Accordingly, the area that can receive the wind of the plural blades (10) as a whole is large.

[0069]

When each of the vertical main shafts (5) rotates a generator not shown mounted inside the base (7) and generated electric powers are collected, the vertical axis windmill (1) as a whole is considered to be one earogenerator that can provide a large amount of electricity.

[0070]

The blades (10) in the third embodiment may be of the two-blade type shown in FIG. 3.

Further, the number of stages of the blades (10) in one shaft-installation section (4a) may differ from that of the stages of the blades (10) in a neighboring shaft-installation section (4a) in such a way that a first shaft-installation section (4a) has five stages, a second one has four stages, a third one has three stages and a fourth one has five stages and so forth, for example. This is advantageous when this vertical axis windmill is installed on an uneven

ground, for example.

[Fourth Embodiment]

[0071]

FIG. 6 is a plan view of essential parts of a vertical axis windmill according to a fourth embodiment of this invention. Wherein, like reference numbers designate like or corresponding parts in the preceding drawings, descriptions of which are thus omitted. In FIG. 6, illustrations of intermediate arms, diagonal braces of the support frame (4) are omitted.

[0072]

According to the fourth embodiment, a number of the shaft-installation sections (4a) are continuously formed, extending in the horizontal direction, inside one support frame (4), and the vertical main shaft (5) is disposed in each of the shaft-installation sections (4a).

In FIG. 6, a plurality of the shaft-installation sections (4a) are connected to one another, extending left to right. As shown in FIG. 6, positions of the shaft-installation sections (4a) are alternately set fore or aft, and positions of the vertical main shafts (5) on a plane of phase are alternately set fore or aft, as well.

[0073]

In FIG. 6, when wind blows in a direction denoted

by an arrow A and blades (10) of the vertical main shafts (5) rotate in a direction denoted by an arrow B, a position that lies to the leeward of the blade (10) is windless.

When wind blows in the left or right direction, a blade behind a blade (10) on the windward side is difficult to catch the wind.

[0074]

When the blade (10) rotates, a layer of the wind (air) rotates over and along the outer surface of the blade (10) because of viscosity of fluid. Accordingly, the wind denoted by the arrow A flows in a direction denoted by an arrow C, and passes through to the back. As a result, wind denoted by an arrow D flows in a direction denoted by an arrow E in FIG. 6 to cause a blade (10) in the lee to rotate.

[0075]

FIG. 7 is a front view of essential parts of a vertical main shaft (5) as a second example. FIG. 8 is a plan view of the vertical main shaft (5). Wherein, like reference characters designate like or corresponding parts in the preceding drawings, descriptions of which are thus omitted.

This vertical main shaft (5) has a short length, and a plurality of the vertical main shafts (5) are connected to one another.

[0076]

On an upper end of the vertical main shaft (5), formed is a fitting projection portion (5b). On a lower end of the vertical main shaft (5), formed is a fitting recess portion (5c). When a plurality of the vertical main shafts (5) are connected, the fitting projection portion (5b) is fitted into the fitting recess portion (5c) of another vertical main shaft (5), and a collar is secured on these portions.

[0077]

When the vertical main shaft is disposed inside the support frame (4), the intermediate bearing (66) contacts the color (5d), and the fixing arm (3) supports them. Whereby, the connecting portions (5b) and (5c) of the vertical main shaft (5) are securely supported by the collar (5d), the intermediate bearing (66), the fixing arm (3) and the like to prevent the vertical main shaft from being bent or being broken.

[0078]

When the length of the vertical main shaft (5) is so set as to match a space between the upper and lower intermediate bearings (66) shown in FIG. 3, the work of carrying and assembling the entire vertical axis windmill (1) becomes easy.

[0079]

FIG. 9 is a front view of essential parts of a vertical main shaft as a third example according to

this invention. FIG. 10 is a plan view of the vertical main shaft. Wherein, like reference characters designate like or corresponding parts in the preceding drawings, descriptions of which are thus omitted.

In this example, a connecting shaft (5e) is prepared, separately from the vertical main shaft (5).

[0080]

As shown in FIG. 9, the vertical main shaft (5) is formed with recessed fitting portions (5f) on both ends thereof. Further, a protruding slip-preventing portion (5g) is formed on each of the fitting portions (5f). A groove-like slip-preventing portion (5h) is formed on edges of both ends of the connecting shaft (5e).

[0081]

In assembling, the lower end of the connecting shaft (5e) is fit into the fitting portion (5f) of the vertical main shaft (5), and the upper end of the connecting shaft (5e) is fit into the fitting portion (5f) at the lower end of the vertical main shaft (5), whereby a plurality of the vertical main shafts (5) can be connected to one another, as shown in FIG. 9.

[0082]

This vertical main shaft (5) may be applied to the vertical axis windmill (1) shown in FIG. 3, for

example. In which case, the connecting shaft (5e) is supported by the intermediate bearing (66) to support the vertical main shaft (5) between the upper and lower intermediate bearings (66), whereby a plurality of the vertical main shafts (5) can be coupled along the height of the support frame (4).

[0083]

The connecting shaft (5e) has a diameter of 2 cm and a length of approximately 10 to 30 cm, for example. Even if the connecting shaft (5e) is given a small diameter, the connecting shaft (5e) is prone not to be bent because the connecting shaft (5e) is short in length and is supported by the bearing (66) at its intermediate portion. A small diameter of the connecting shaft (5e) allows use of a small bearing, and has a small frictional resistance because the small diameter has a small friction area, which provides excellent rotation efficiency. In maintenance, it is possible to replace only the connecting shaft (5e).

If a protruding fitting portion is formed on one end of the connecting shaft (5e) while a recessed fitting portion is formed on the other end of the same, the connecting shaft (5e) can be connected to the fitting projection portion and the fitting recess portion of the vertical main shafts (5) shown in FIG. 7.

[0084]

The vertical main shaft (5) has a diameter of 4 cm and a length of approximately 150 to 200 cm, for example.. It is possible to cover the surface of the vertical main shaft (5) by the reinforcement member (5a) when necessary to keep the rigidity.

Since the length of the vertical main shaft (5) is short and the number of the attached blades (10) is two at most, the vertical main shaft (5) is prone not to be bent even when given a small diameter, and the small diameter of the vertical main shaft (5) is effective to reduce the weight.

[0085]

Note that the present invention is not limited to the above embodiments and examples, but may be suitably modified within the scope of the invention. For instance, the number of the support arms (8) may be three for each blade or each pair of blades, or diagonal braces may be disposed.

[Industrial Applicability]

[0086]

By connecting a generator to the vertical main shaft, the vertical axis windmill can be served as an aerogenerator, or can be used for pumping, flour mill and other industrial power.

[Brief Description of the Drawings]

[0086]

[FIG. 1] Front view of essential parts of a vertical axis windmill according to a first embodiment of this invention;

[FIG. 2] Plan view of essential parts of the vertical axis windmill according to the first embodiment of this invention;

[FIG. 3] Front view of essential parts of a vertical axis windmill according to a second embodiment of this invention;

[FIG. 4] Plan view of essential parts of the vertical axis windmill according to the second embodiment of this invention;

[FIG. 5] Front view of essential parts of a vertical axis windmill according to a third embodiment of this invention;

[FIG. 6] Plan view of essential parts of a vertical axis windmill according to a fourth embodiment of this invention;

[FIG. 7] Front view of essential part of a vertical main shaft in a second example;

[FIG. 8] Plan view of the vertical main shaft in FIG. 7;

[FIG. 9] Front view of essential parts of a vertical main shaft in a third example; and

[FIG. 10] Plan view of the vertical main shaft in FIG. 9.

[Explanations of letters or numerals]

[0088]

(1) … vertical axis windmill

(2) … post

(3) … fixing arm

(4) … support frame

(4a) … shaft-installation section

(5) … vertical main shaft

(5a) … reinforcement member

(5b) … fitting projection portion

(5b) … fitting recess portion

(5c) … collar

(5e) … connecting shaft

(5f) … fitting portion

(5g)(5h) … slip-preventing portion

(6) … bearing

(66) … intermediate bearing

(7) … base

(8) … fixing member

(9) … support arm

(10) … blade

(10a) … tilted part